

lymphatic system, and, in the most extreme cases, the eye. Climate affects the occurrence of onchocerciasis because the vector requires fast-flowing water for successful reproduction (WHO, 1985), and the adult vector can be spread by wind.

A recent simulation study on the potential impact of climate change on blackfly populations in West Africa showed that if temperature and precipitation were to change across parts of the sub-Saharan, as predicted by the Goddard Institute for Space Studies (GISS) GCM (Hansen *et al.*, 1988), blackfly populations may increase by as much as 25% at current breeding sites (Mills, 1995). Since these vectors can travel hundreds of kilometers on wind currents, new habitats in previously unsuitable areas could be quickly colonized by blackflies, introducing onchocerciasis into new areas (Garms *et al.*, 1979; Walsh *et al.*, 1981; WHO, 1985).

#### 18.3.1.6. Trematode Infections

Some trematode infections, such as fascioliasis (a liver fluke that currently affects around 2.4 million persons), would be affected by climate changes because the life cycle and population size of the snail host are very sensitive to temperature. Similarly, the incidence of cercarial dermatitis (skin inflammation) would be increased at higher temperatures. This infection is currently found in Europe (Beer and German, 1994) and the United States (CDC, 1992), where it causes “swimmer’s itch”; its incidence has recently increased in Russia (Beer and German, 1993) and in very poor rural communities in developing countries.

#### 18.3.1.7. Vector-Borne Viral Infections

Many vector-borne infective agents are viruses. The human-infecting arboviruses (i.e., arthropod-borne viruses) generally have a mosquito vector. Arboviral infections span a wide clinical spectrum, from those that cause mild feverish illness or subclinical infections to those causing severe and often fatal encephalitis (brain inflammation) or hemorrhagic fever. Under favorable environmental conditions, an arboviral disease can become epidemic (population-wide), from a local endemic base or by its introduction to a previously unaffected area. The distribution and abundance of vectors are influenced by various physical factors (temperature, rainfall, humidity, and wind) and biological factors (vegetation, host species, predators, parasites, and human interventions) (WHO, 1990). Temperature also affects the rapidity of the virus’ life cycle—e.g., the extrinsic incubation period for the mosquito-hosted stage of the yellow fever virus varies from several weeks to 8–10 days, depending on temperature.

Increased temperature and rainfall in Australia would influence the range and intensity of various vector-borne viral infections. For example, certain arthropod vectors and natural vertebrate hosts would spread southward and proliferate in response to warming and increased rain, resulting in increased incidence of arboviral infections such as Murray Valley encephalitis (which

can cause serious brain damage), Ross River virus (which causes multiple, often long-lasting joint inflammation), and dengue (e.g., Sutherst, 1993; Nicholls, 1993).

Dengue is a severe influenza-like disease, which in some cases may take the form of a hemorrhagic fever, which can cause an average of 15% mortality without proper medical attention. Dengue is transmitted by the *Aedes aegypti* mosquito, as is urban yellow fever. In parts of Asia, dengue also is transmitted by *Ae. albopictus*, which now is colonizing North and South America. Research in Mexico has shown that an increase of 3–4°C in average temperature doubles the rate of transmission of the dengue virus (Koopman *et al.*, 1991). Although there is no clear evidence of regional climatic influence, annual epidemics of dengue have returned to Central America over the past decade (as they did about twenty years ago in Asia), and, in Mexico, dengue has recently spread to previously unaffected higher altitudes (Herrera-Basto *et al.*, 1992). *Ae. aegypti* mosquitoes, once limited to 1,000 meters altitude by temperature in Colombia, have been recently reported above 2,200 meters. The habitat of the mosquito is restricted to areas with a mean midwinter temperature of more than 10°C. Epidemic transmission of dengue is seldom sustained at temperatures below 20°C (Halstead, 1990).

#### 18.3.1.8. Other Vector-Borne Diseases

VBDs are now relatively rare in most developed countries; however, it has been predicted that various VBDs might enter or increase in incidence in the United States because of higher temperatures (Longstreth, 1989; Freier, 1993; Martens *et al.*, 1994); Venezuelan equine encephalitis, dengue, and leishmaniasis could extend into the southern United States; Western equine encephalitis might move further north within the United States (Reeves *et al.*, 1994). The dengue-transmitting *Ae. albopictus* mosquito, which is more cold-hardy than *Ae. aegypti*, is now well established in the United States and may extend toward Canada if temperatures increase.

Climate change would influence the global pattern of VBDs via other disturbances of ecological relationships. For example, it would bring together vertebrate animals of different species and would thereby expose animals to new arthropod vectors. Warming (and rising sea levels) would displace some human populations, perhaps resulting in migration into wilderness areas where zoonotic infectious agents are being transmitted in silent wildlife cycles. Migratory humans would thus be at risk of infection with enzootic (i.e., locally prevalent animal-infecting) agents. Climate-induced changes in ecology also could force the rapid evolution of infectious agents, with newly emergent strains of altered virulence or pathogenicity. Additionally, changes in climate means and variability can disrupt predator/prey ratios, thus loosening natural controls on pests and pathogens.

Two other general points should be noted. First, because vector control methods exist for many of these diseases, developed